International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 3, ISSN No. 2455-2143, Pages 342-348
Published Online July 2019 in IJEAST (http://www.ijeast.com)

FINITE ELEMENT ANALYSIS OF COMPOSITE CONCRETE SLAB WITH PROFILED STEEL DECKING FOR DIFFERENT SHEAR SPANS

Suraj Vilas Bhise
Student, M. Tech Structural Engineering,
Applied Mechanics Department,
Government College of Engineering, Karad,
Maharashtra, India

U. L. Deshpande
Professor,
Applied Mechanics Department,
Government College of Engineering, Karad,
Maharashtra, India

Abstract— **Composite roof slabs are demanding due to fast, light and economical construction work. Composite slabs consist of roof profile sheets formed in cold and concrete (light or moderate). This study studies the results of analysis and modeling of the FE of composite slabs to predict the stress-strain behavior, performance resistance and load deflection behavior. The investigation of the bending behavior of composite slabs is very complex. In this study, finite element analysis was performed using ANSYS 16.0, and the bending behavior of composite slabs was investigated. In this study, Is considered as a composite slab that can be examined briefly. Other parameters change, sheet thickness and cutting span. Cold forming cover profile the blades, that is, several cutting sections with intermediate reinforcements and without intermediate reinforcements, are considered three thicknesses (0.8 mm, 1.0 mm and 1.2 mm) for simulation purposes. In the present study, a model simulation of a static mesh load of 25 mm was considered. Flexural strength is also called transverse strength or flexural strength.**

Keywords— **Slab, Finite Element Analysis, ANSYS Workbench, Yield capacity, Stress-Strain behaviour, Deflection.**

I. INTRODUCTION

Cold formed steel is widely used in composite floor decks and is permanently maintained as an integral part of the floor system. They perform two functions. It serves as a concrete formwork and concrete slabs and acts as a tensile reinforcement. The only additional steel that must be provided is to manage the shrinkage and temperature. For continuous slabs, the reinforcing steel must withstand the negative bending moments in the supports. This type of flooring results in faster construction, lighter floors and reasonable use of building materials. They also offer other benefits, such as easy handling, good roof surfaces and conduits suitable for routing services of public services. Finally, the thin sheet is very light and can be conveniently transported, easy to handle and placed by construction personnel. Some of the disadvantages observed for the system are the need to protect against inadequate fire resistance, the need for proper coupling between the steel platform and the concrete, and the damage of high local loads. Even if the steel platform is galvanized, it is recommended to apply anticorrosive paint to the exposed surface. Molding effects and edge deformation must also be handled during design. The term 'composite steel deck slab' means that there are regulations in systems that combine concrete slab with steel deck by some mechanical means. In other words, a mechanical lock is required for a combination of steel and concrete platform. Basically, this is provided by various 'shear transfer devices', such as shear studs, embossing, cable routing, holes, etc. An example of a composite steel deck floor slab is shown in Figure1.

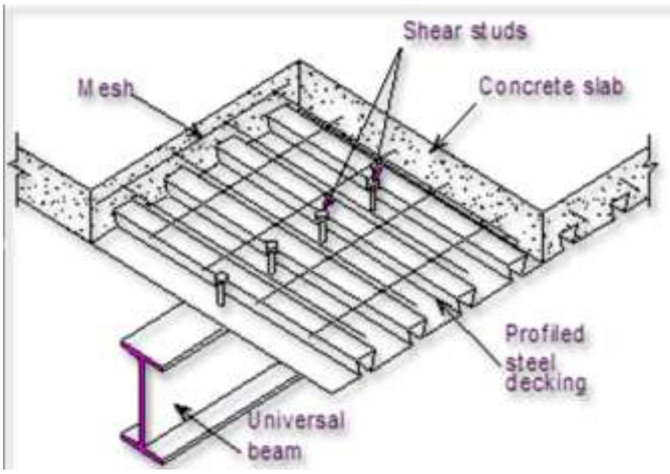

Fig. 1. Composite steel deck floor slab

II. METHODOLOGY

A. Structural Modelling –

The finite element model of the slab is made of concrete and steel profile platforms with non-linear material properties.

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Nonlinear 3D FE modelling and slab element analysis is performed using ANSYS 16.0. The dimensions of the structure are 820 x 3000 mm, the effective depth is 77.5 mm and the height is 105 mm. The profile sheets of the cold forming platform are 55 mm high and 0.8 mm, 1.0 mm and 1.2 mm thick respectively. In ANSYS 16.0, the properties of steel and concrete materials can be characterized by uniform materials. The boundary condition is articulated at one end (U1 = U2 = U3 = 0) and the other end has a roller (U1 = U2 = 0). These two parts consist of a linear hexahedral element and eight noded elements with a mesh size of 25 mm. The specimens were divided into 10 shear span sizes of 3 sets of specimens, 5 sets were analyzed to detect shorter shear span loads and another 5 sets were analyzed to determine the longest shear span loads. Shear spans of 300 mm, 400 mm, 450 mm, 500 mm and 600 mm were selected for short-span interval loads, but 750 mm, 850 mm, 900 mm, 1000 mm and 1200 mm were selected for long span loads. For each set of samples of three different thicknesses, each sample was tested up to yielding in a four-point load test.

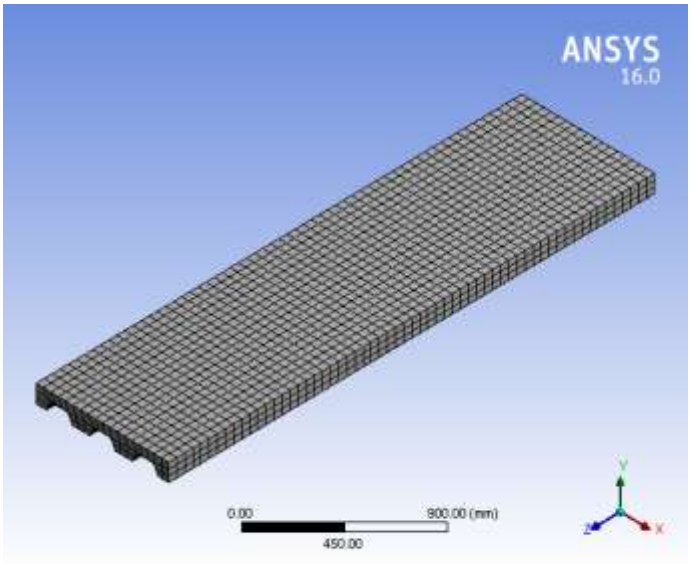

Fig. 2. FE Modelling and Meshing

B. Load, Boundary condition and Numerical control –

The end of the slab is provided with a roller support and a hinge support. The edge of the steel platform along the length of the slab and the node on the concrete side side of the central section receive the appropriate boundary conditions to simulate the lateral continuity of the slab. This greatly reduces the size of the model and the calculation time. The load is applied at a specific distance from the end supports to two line loads with a value of 121.95 N / mm. Therefore, the result will be two point loads of magnitude 100 kN that will be applied to the higher fiber nodes of the concrete (Figure 3). The tolerance associated with this convergence criterion (ANSYS CNVTOL command) and the increments of the loading steps are varied to solve possible numerical problems. The Newton-Raphson method is used as the incremental-iterative solution process.

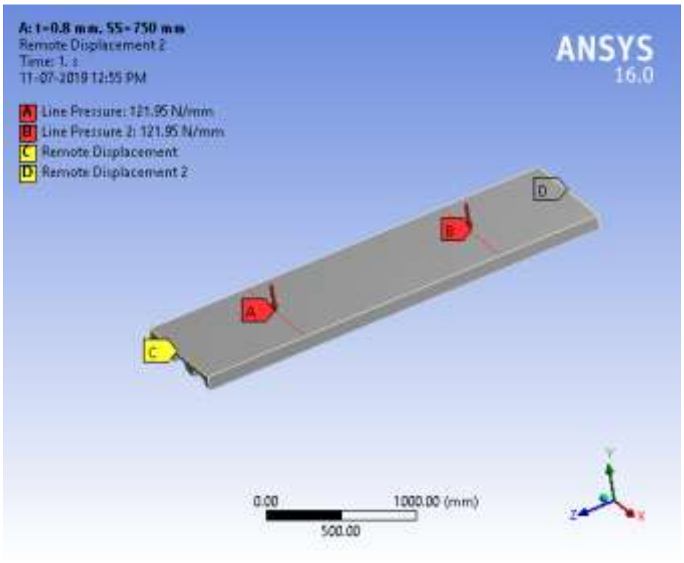

Fig. 3. Loads and boundary conditions

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C. Material Specifications –

Table - 1 Concrete properties used in the FE model

Concrete Properties	Value
Density	**2400 kg/m^3**
Young's modulus	**5000$\sqrt{fck}$**
Yield strength	**25 N/mm^2**
Poisson's ratio	**0.18**

Table - 2 Steel properties used in the FE model

Steel Properties	Value
Density	**7800 kg/m^3**
Young's modulus	**2 x10^5 N/mm^2**
Yield strength	**250 N/mm^2**
Poisson's ratio	**0.3**

D. Preparation of the composite slab model –

Two loading plans have been selected, one for short shear spans and the other for long shear intervals to form the two ends of the shear span section. Five series of shear spacing shorter than 300 mm, 400 mm, 450 mm, 500 mm and 600 mm have been selected. The criterion for the longest shear section is that the shear section should be as long as possible and should provide failure in the longitudinal section. Therefore, the longer the shear span, the more the values of 750 mm, 850 mm, 900 mm, 1000 mm and 1200 mm were selected. For comparison, the thickness of steel platform slabs such as 0.8 mm, 1.0 mm and 1.2 mm are different.

III. ANALYTICAL CALCULATIONS

The expression used here to calculate the maximum deflection of a slab in a flexural analysis. Simply deflection of the supported section.

$$\Delta\,\text{max} = \frac{F \times a\,(3L^2 - 4a^2)}{24\ EI}$$

Where, F is load applied, L is total span, a is shear span, E is combined modulus of elasticity and I is moment of inertia of composite section.

The elastic stiffness calculations are based on the steel that has been transformed into a concrete member equivalent to a simple supported boundary condition. In the case of stiffness calculations, the average value of the moment of inertia is cracked and the values not cracked. The moment of inertia cracked and not fractured is calculated using the following equation, which is an amendment to the ASCE standard equation (Specification 1984).

Moment of Inertia for Cracked section :

$$I_{Cr} = \frac{b}{3}(y_{CC})^3 + nA_S(y_{CS})^2 + nI_{sf})$$

Moment of Inertia for uncracked section :

$$I_{un} = \frac{bh_C^3}{12} + bh_C(y_{cc} - 0.5h_C)^2 + nI_{sf} + nA_5 y_{cs}^2 + \frac{W_r.b\,d_d}{C_5}\left[\frac{d_d^2}{12} + (h - y_{CC} - 0.5d_d)^2\right]$$

IV. RESULTS AND DISCUSSIONS

The following is a simulation of 30 models in ANSYS 16.0. The results are divided into 6 groups according to the cold-formed roof profile sheets 0.8 mm thick with and without intermediate reinforcements and 1.2 mm thick with or without intermediate reinforcements according to different cutting intervals (850 mm, 950 mm, 350 mm and 380 mm). The deflection and deformation deformation patterns for one of the models are shown in Figures 6 and 7, respectively. Obtain a variation pattern for the rest of the model in a similar way.

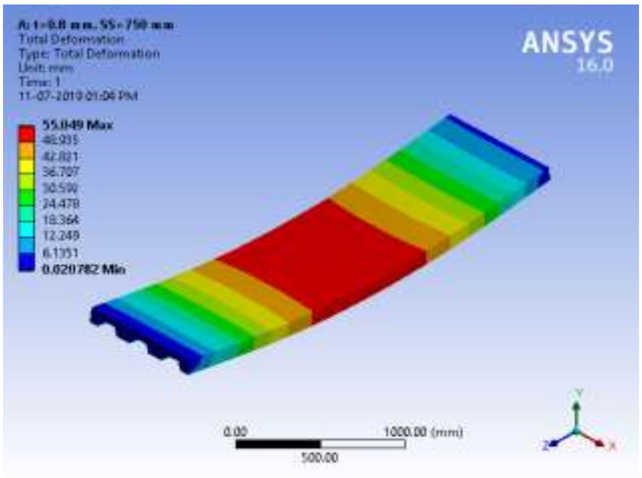

Fig. 4. Deformation of composite slab

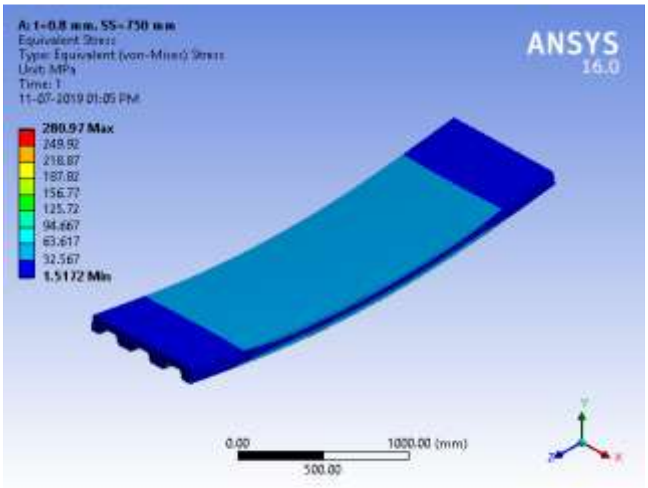

Fig. 5. Equivalent Stress in Composite Slab

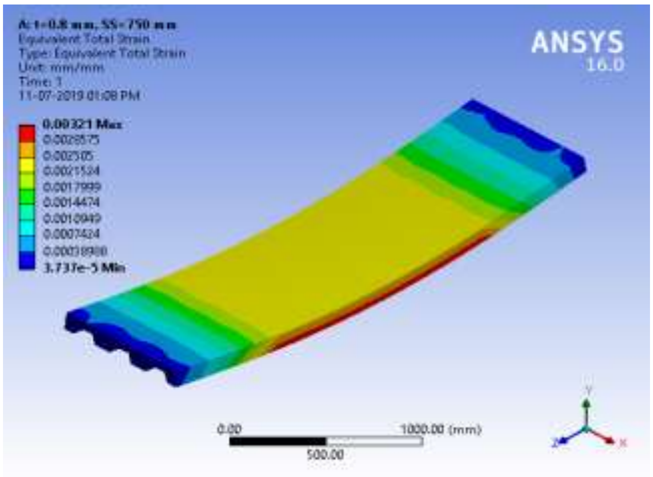

Fig. 6. Equivalent Strain in Composite Slab

From the stress and strain values obtained from the analysis, the typical Stress-Strain plots are drawn in ANSYS software

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results. Each shear span gives different values of maximum von-mises equivalent stress and maximum total strain values. Slabs with long shear spans show yield at low loads and short shear span slabs show yielding at greater values. But the modulus of elasticity for the model remains constant. Some of the Stress-Strain graphs are shown below:

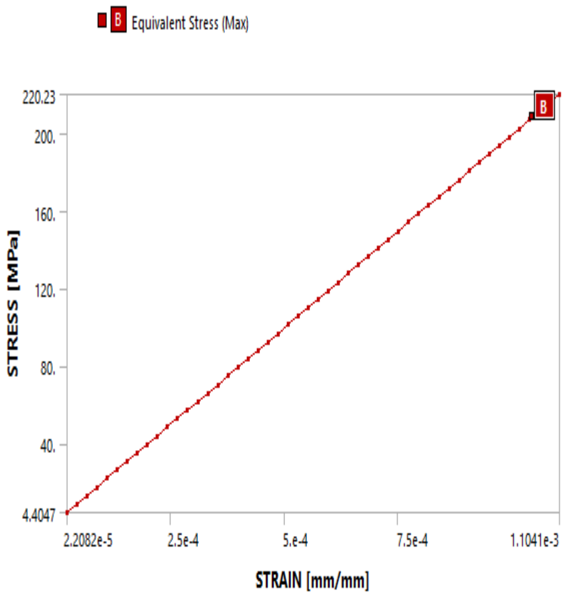

Chart 1. Stress-Strain for Shear span = 300 mm

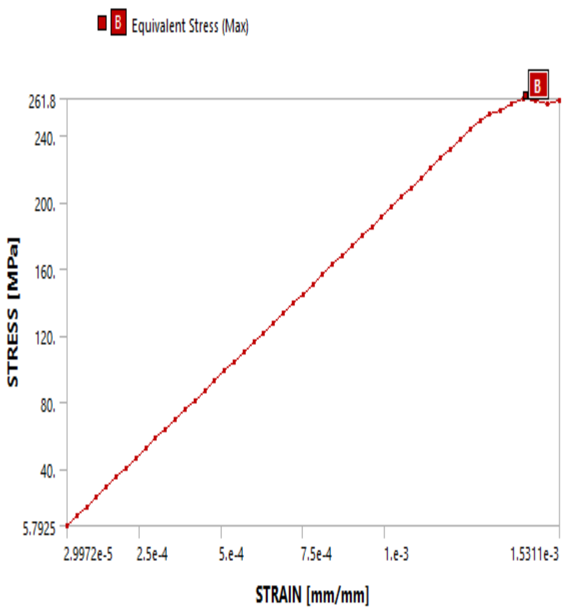

Chart 2. Stress-Strain for Shear span = 400 mm

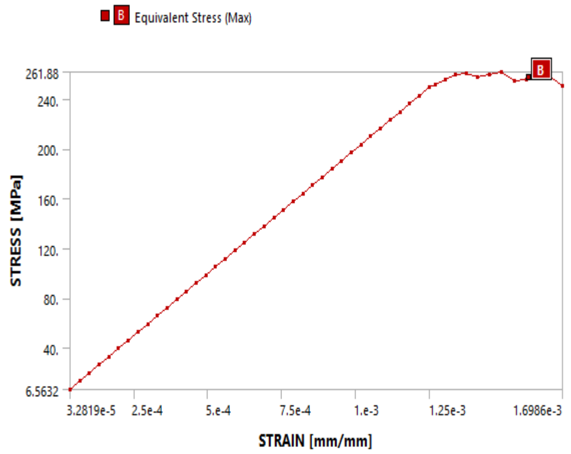

Chart 3. Stress-Strain for Shear span = 450 mm

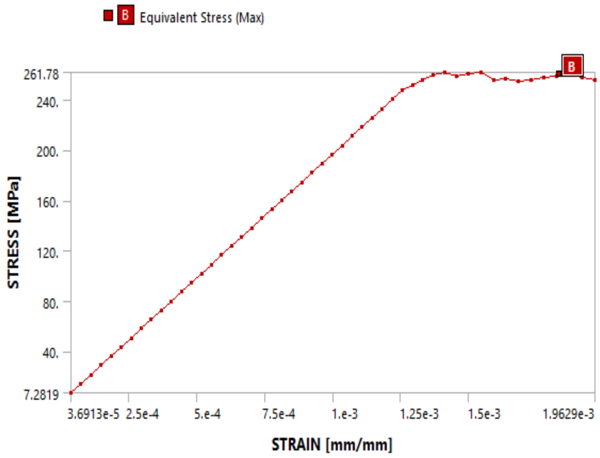

Chart 4. Stress-Strain for Shear span = 500 mm

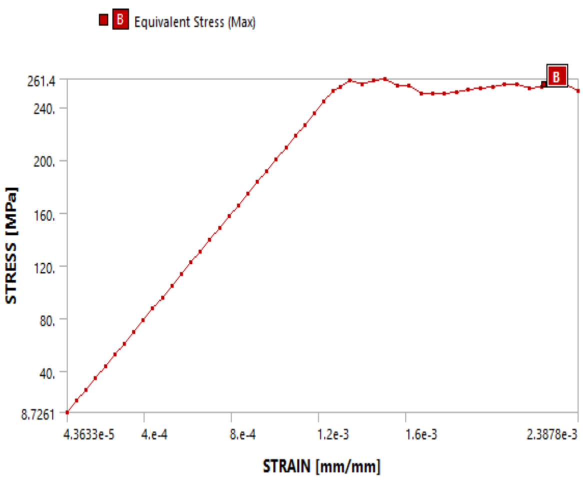

Chart 5. Stress-Strain for Shear span = 600 mm

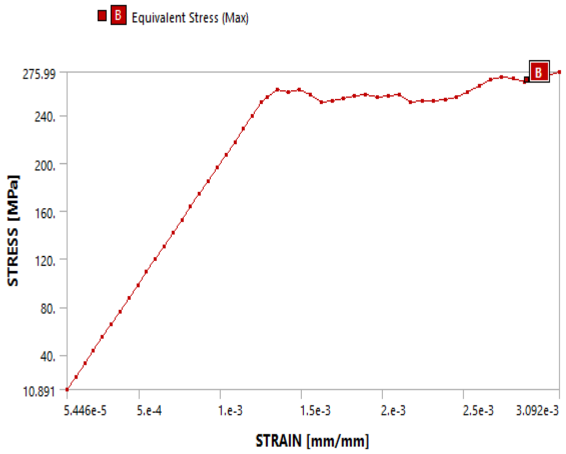

Chart 6. Stress-Strain for Shear span = 750 mm

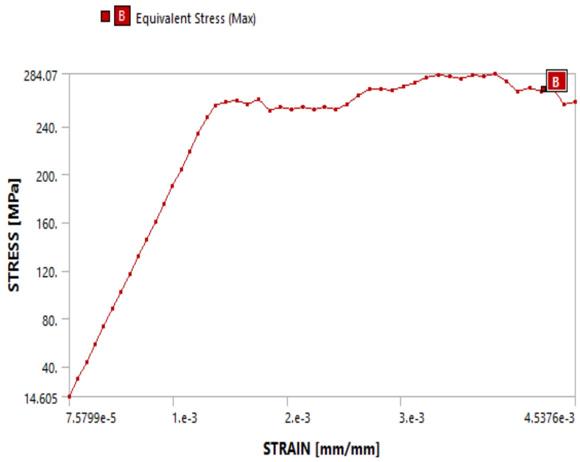

Chart 9. Stress-Strain for Shear span = 1000 mm

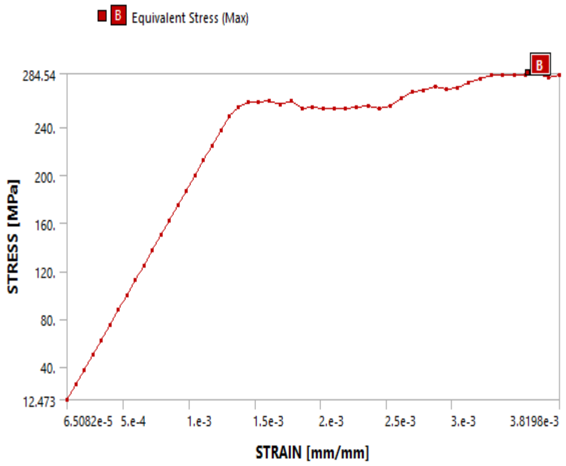

Chart 7: Stress-Strain for Shear span = 850 mm

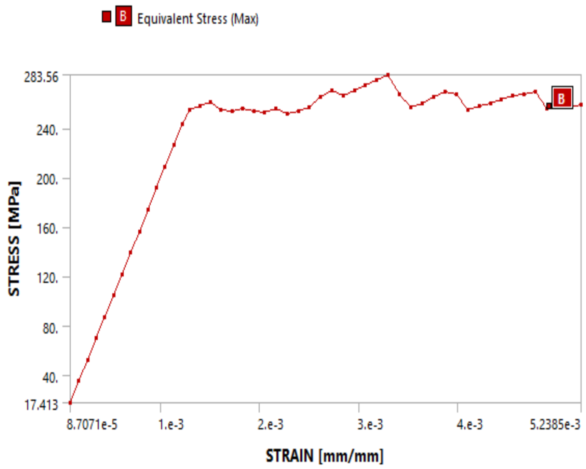

Chart 10. Stress-Strain for Shear span = 1200 mm

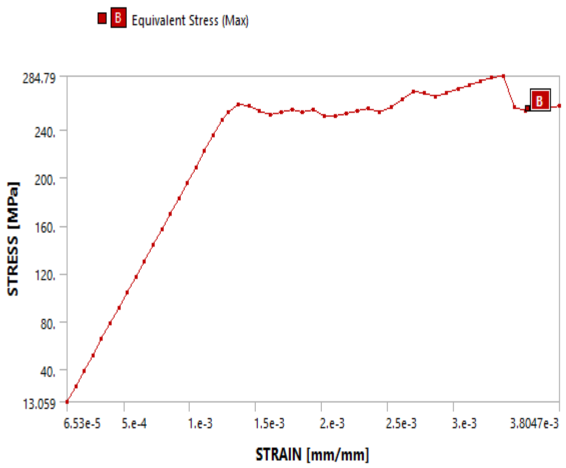

Chart 8. Stress-Strain for Shear span = 900 mm

The results of the 0.8 mm steel cover thickness are shown above for 10 different values of shear spans. Five series of shorter cutting intervals of 300 mm, 400 mm, 450 mm, 500 mm and 600 mm were chosen and for longer shear spans, values of 750 mm, 850 mm, 900 mm, 1000 mm and 1200 mm were chosen.

Results obtained from the simulation of 30 models in ANSYS Workbench 16.0. The stress-strain curves are plotted with different shear spans shows that the tables with the highest shear spans produce first, and more time and larger load values are required for the shorter cutting periods to produce and reach their limits deformation.

Table -3 Yield Capacity of Composite slab specimens

Steel deck thickness (mm)	Shear Span (mm)	Yield Load (kN)	Deflection (mm)	Equivalent Stress (N/mm^2)	Equivalent Strain
0.8	750	88	22.123	250.94	1.25E-03
0.8	900	72	20.854	246.73	1.23E-03
0.8	1200	56	19.342	252	1.27E-03
1.0	750	92	22.207	250.5	1.25E-03
1.0	900	76	21.136	248.12	1.24E-03
1.0	1200	60	18.570	255	1.29E-03
1.2	750	96	22.300	249.06	1.25E-03
1.2	900	80	21.413	248.87	1.24E-03
1.2	1200	64	19.150	248.89	1.24E-03

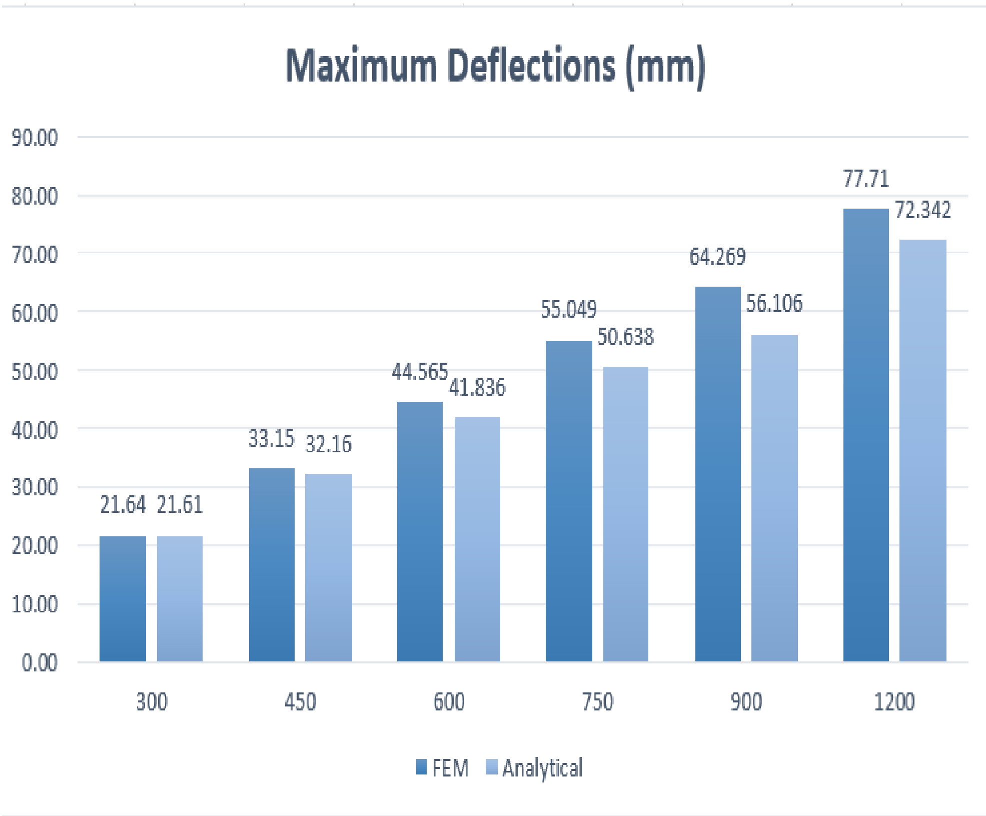

Chart 11. Maximum deflection comparison FEM and Analytical values

V. CONCLUSION

A simulative approach to determine the performance resistance of composite slabs has been presented. The approach is based on the analysis of finite elements with the help of ANSYS Workbench 16.0. The results of 30 different samples are verified with FE analysis. It is observed that the cutting time affects the resistance of the slab sample. For large sections of cut, only the flexural strength decides the fault while the short sections fail in the cut.

A comparison between analytical and simulation studies shows that we can use computer-assisted results as an option for experimental tests.

- Simulation results of composite slabs for 0.8 mm thickness show that the maximum deflection values by ANSYS and analytical calculations vary by 1-10 % on the higher side for both long and short shear spans.
- Results of composite slabs for maximum deflections decreases by 3-5 % with an increase in the thickness of the steel deck for short as well as long shear spans.
- Yield capacity of composite slab increases with increase in the thickness of deck sheet by about 5% whereas it decreases with an increase in shear span.

VI. Acknowledgement

I take this opportunity to express my deep sense of gratitude towards my guide U. L. Deshpande, Professor, Applied Mechanics Department, Government College of Engineering, Karad and my co-guide Dr. M. R. Shiyekar, Professor, Applied Mechanics Department, Government College of Engineering, Karad.

I extent my sincere thanks to Dr. A. T. Pise, Principal, Government College of Engineering, Karad and Dr. Y. M. Ghugal, Head, Applied Mechanics Department, Government College of Engineering, Karad for providing institutional facilities and extending all kinds of co-operation. I am thankful to all the faculty members of Applied Mechanics, Civil Engineering Department and Library whose guidance and help have been immensely useful in my work.

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